

STATUS AND SPREAD OF THE PALEARCTIC LADY BEETLES *HIPPODAMIA VARIEGATA* AND *PROPYLEA QUATUORDECIMPUNCTATA* (COLEOPTERA: COCCINELLIDAE) IN PENNSYLVANIA, 1993-1995¹

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ABSTRACT: The adventive lady beetles *Hippodamia variegata* and *Propylea quatuordecimpunctata* were detected in Pennsylvania in 1992 and 1993, respectively. Surveys of these aphid predators were conducted during 1993-1996 to document their westward dispersion from counties bordering on the Delaware River; their distribution in eastern Pennsylvania is mapped for the first three seasons. Twelve coccinelline Coccinellidae, both indigenous and nonindigenous species, were collected during the first three seasons; the number of sites at which each was found is recorded. Our surveys document explosive colonization of the state by *Harmonia axyridis*, corroborate evidence of a precipitous decline in numbers of *Coccinella novemnotata* in much of eastern North America, and support the idea that *Hippodamia convergens* is no longer a dominant coccinellid in herbaceous habitats in the northeastern states.

Classical biological control as an effective strategy of insect suppression began with the use of a coccinellid. In the late 1880s the vedalia, *Rodolia cardinalis* (Mulsant), was released to suppress populations of the cottony cushion scale, *Icerya purchasi* Maskell, in California (Essig 1931, DeBach 1964, Hagen and Franz 1973). The project's spectacular results triggered a "ladybird fantasy": a period of inordinate emphasis on exotic coccinellids, characterized by overzealous and generally unsuccessful importation and establishment of additional species (Greathead 1995). Interest in coccinellids for pest suppression eventually gave way to the use of parasitic Hymenoptera and later to synthetic organic insecticides. Ultimately, a more scientific approach to biological control was adopted, the reliance on insecticides lost favor, and interest in coccinellids was revived during the 1960s and 1970s (Gordon 1985, Waage and Greathead 1988, Greathead 1995).

The past 25 years have been marked by changes in the coccinellid fauna of the northeastern United States: establishment of nonindigenous species through either intentional releases for biocontrol purposes or unintentional introductions with commerce, coupled with an apparent decline in numbers of certain native species. Studies on adventive lady beetles during this period have included life histories (e.g., Rogers *et al.* 1972, Michels and Bateman 1986); introduction, evaluation, rearing, release, and redistribution (e.g., Shands *et al.*

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1972, Angalet *et al.* 1979); monitoring of establishment and spread (Schaefer *et al.* 1987, Ellis and Adams 1993, Wheeler 1993, LaMana and Miller 1996, Hoebeke and Wheeler 1996); attempts to determine the origin of North American populations — i.e., deliberate releases or unintentional introductions with commerce (e.g., Schaefer and Dysart 1988, Krafur *et al.* 1992, Day *et al.* 1994); and taxonomic recognition (Gordon and Vandenberg 1991). Attention has also been given to possible adverse effects of *Coccinella septempunctata* L. and other adventive lady beetles on populations of native coccinellids, and to changes in structure of native lady beetle communities (Day *et al.* 1994, Wheeler and Hoebeke 1995, Elliott *et al.* 1996).

Since the late 1970s, four Old World species of the coccinelline tribe Coccinellini have become established in Pennsylvania: *C. septempunctata*, *Harmonia axyridis* (Pallas), *Hippodamia variegata* (Goeze), and *Propylea quatuordecimpunctata* (L.) (Hoebeke and Wheeler 1980, Ellis and Adams 1993, Wheeler 1993, 1995, unpubl. data). Pennsylvania participated in the 1993 multistate coccinellid project funded by the USDA Animal and Plant Health Inspection Services' Cooperative Agricultural Pest Survey. The main goal of that project was to determine the distribution of *H. variegata* (HV) and *P. quatuordecimpunctata* (PQ) from Maine to Virginia; information derived from surveys in eastern United States was hoped to enhance biological control efforts against the Russian wheat aphid, *Diuraphis noxia* (Mordvilko), in the western states (Flanders *et al.*, 1993). These two lady beetles — recorded from eastern Canada (Gordon and Vandenberg 1991, McNamara 1991), all New England states, New York, New Jersey, and Pennsylvania— were determined to be extending their range southwesterly (Ellis and Adams 1993).

According to Ellis and Adams, future surveys "should continue to delineate the leading edge of HV and PQ populations." We, therefore, have continued to monitor the westward spread of these species in eastern Pennsylvania, where populations were restricted initially to counties on or near the Delaware River, and present herein the results of surveys during 1993-1996. We also discuss the status of *C. septempunctata* (C7) and *H. axyridis* in Pennsylvania, record the native species of Coccinellini collected during surveys for adventive lady beetles, and comment on the possible decline of certain native lady beetles in the state.

METHODS

Following the detection of HV in Pennsylvania in 1992, more extensive surveys were made in 1993 for both HV and PQ. Three alfalfa fields were surveyed in Monroe, Northampton, and Wayne counties; 1,500 sweeps were taken six times in each field from mid-June to early September (see Ellis and Adams 1993 and Wheeler and Hoebeke 1995 for details). Sweepnet sampling at 52 additional sites was conducted during the same period, emphasizing herbaceous vegetation in disturbed sites such as urban vacant lots and railroad yards and

rights-of-way. Aphid-infested plants most often sampled were horseweed, *Conyza canadensis* (L.) Cronq.; spotted knapweed, *Centaurea biebersteinii* DC.; and sweet clover, *Melilotus* spp. The time spent at each site varied, but nearly always included at least 15 minutes of observation and sweepnet sampling (several hundred sweeps). Because the sweepnet sampling of forbs at various ruderal sites proved efficient for detecting adventive lady beetles, similar sampling was conducted in 1994 from mid-June to late August (136 sites in 23 counties), in 1995 from mid-June to mid-August (124 sites in 17 counties), and in 1996 from late June to late August (69 sites in 18 counties). Each season we emphasized areas west of previous detection sites.

Specimens that could not be identified accurately in the field were collected for later verification. Voucher material from our surveys is deposited in the Pennsylvania Department of Agriculture insect collection.

RESULTS

Following the detection of HV in 1992 in three counties that border on the Delaware River, this recent invader was found only in three new counties (Delaware, Monroe, and Northampton) in 1993 (Fig. 1A). Sampling that year failed to yield specimens in 11 counties that lie just west of those along the river; also negative were attempts to collect it in Bucks Co., which borders the river in the southeast. In 1994, HV was found in 14 additional counties; the westernmost collections were from the eastern portions of Bradford, Sullivan, Columbia, Schuylkill, Berks, and Chester counties. By 1995, the western spread of HV reached at least the middle of Tioga Co. in the north, but with the exception of a record from western Columbia Co., all collections south of Tioga Co. were negative. In 1994 and 1995, this species was not found at several sites near localities that were positive the previous season(s). Surveys in 1996 resulted in 11 new county records (not shown in Fig. 1), including five that lie west of the Susquehanna River.

The first records of PQ in Pennsylvania were obtained in 1993 from some of the same sites where HV had been detected the previous year (Fig. 1B). At the end of 1993, PQ had been found in more counties (8) and sites (12) than had HV (6 counties, 10 sites), but its subsequent westward spread has been less than that of HV. Only one new county, Luzerne, was added in 1994, and PQ was not collected in 1995 surveys that included 17 counties lying west of known populations in the state. PQ also was not found in 1996.

In addition to the adventive HV and PQ, two other nonindigenous coccinellids — C7 and *Harmonia axyridis* — were collected. The former species, which was first found in Pennsylvania in 1979 (Hoebeke and Wheeler 1980), now occurs statewide (Flanders *et al.* 1993, A.G.W. unpubl. data). The latter species, known as the multicolored Asian lady beetle, was first collected in Pennsylvania in 1993 (Wheeler 1995). It was not, however, encountered that year during our surveys for HV and PQ, but it was taken at 16 sites in 1994. The following year, it was collected at 52 sites, more than for any of the other coccinellids,

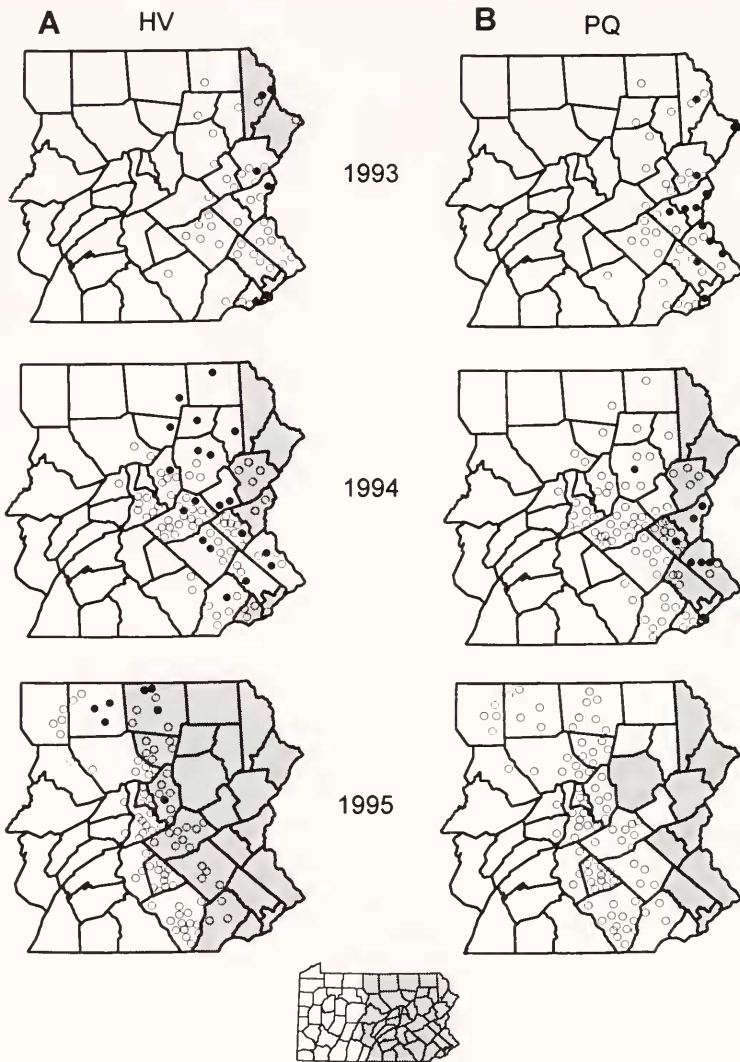


Fig. 1. Occurrence of *Hippodamia variegata* (1A: HV) and *Propylea quatuordecimpunctata* (1B: PQ) in eastern Pennsylvania, 1993-1995. Sites where species were found (●) and were not found (○) are shown; not all sites sampled are mapped because of their proximity. See text for sampling methods. Shading denotes counties positive in previous years. Shaded area of small map at bottom indicates counties surveyed in eastern Pennsylvania.

indigenous or adventive (Table 1). *Harmonia axyridis* has now dispersed throughout the state, occurring not only on forbs in ruderal sites, but also on alfalfa, small grains, and various trees and shrubs (A.G.W. unpubl. data). Among the four adventive coccinellids, C7 occurred at far more sites in 1993-1994 than the other three species, but it was found at only 18 sites (vs. 52 for *H. axyridis*) in 1995.

The most commonly collected native coccinellids during the first three seasons were *Coleomegilla maculata lengi*, *Cycloneda munda*, and *Hippodamia parenthesis* (Table 1). Native species each found at only one site (single individuals) were *Coccinella transversoguttata richardsoni* and *H. glacialis*. *Coccinella trifasciata perplexa* was generally seen only in the more northern counties, and the convergent lady beetle, *H. convergens*, was collected only six times during 1993-1995. *Coccinella novemnotata*, once common in Pennsylvania and the northeast (Wheeler and Hoebeke 1995), was not encountered during our fieldwork.

Table 1. Adult coccinellids (tribe Coccinellini) collected during surveys for *H. variegata* and *P. quatuordecimpunctata* in eastern Pennsylvania, 1993-1995; asterisks indicate adventive species.

Species	No. of Sites		
	1993	1994	1995
<i>Adalia bipunctata</i> L.	6	2	6
* <i>Coccinella septempunctata</i> L.	57	46	18
<i>C. transversoguttata richardsoni</i> Brown	0	0	1
<i>C. trifasciata perplexa</i> Mulsant	6	0	2
<i>Coleomegilla maculata lengi</i> Timberlake	37	58	51
<i>Cycloneda munda</i> (Say)	14	14	27
* <i>Harmonia axyridis</i> (Pallas)	0	16	52
<i>Hippodamia convergens</i> Guerin	4	1	1
<i>H. glacialis</i> (F.)	1	0	0
<i>H. parenthesis</i> (Say)	30	27	14
* <i>H. variegata</i> (Goeze)	10	18	7
* <i>Propylea quatuordecimpunctata</i> L.	19	8	0

DISCUSSION

Our surveys document the southwestward spread of the adventive coccinellids HV and PQ in Pennsylvania during 1993-1996. The pattern of positive and negative sites is reasonably consistent for both species, with HV's spread exceeding that of PQ. The leading edges of their populations, though, most likely lie somewhat west of those shown in each of the three years. Extremely

low densities would have gone undetected at our sample sites, and populations undoubtedly existed in areas not covered by our fieldwork. Our surveys also serve to record the quite recent invasion and explosive colonization of *Harmoina axyridis* in the state.

We would be premature in drawing conclusions regarding a decline in numbers of the convergent lady beetle, *Hippodamia convergens*. This native species was collected at few sites each season, and it was similarly uncommon during surveys for HV and PQ in the northeast during 1992 and 1993 (Ellis and Adams 1993, Wheeler 1993). But coccinellid populations can fluctuate widely between years (see Wheeler and Hoebeke 1995, Elliott *et al.* 1996), and some species probably vary in abundance in different habitats from year to year, depending on availability of aphid prey. Our failure to collect *Coccinella novemnotata* does, however, corroborate a definite trend of declining numbers in the northeast, where this once common native lady beetle may be locally extirpated (Wheeler and Hoebeke 1995).

Among potential factors that could be responsible for declining populations of native coccinellids, adverse effects from C7 have been mentioned most often. As Ehler (1990) noted, it seems likely that this dominant, Old World coccinellid will have some impact on nontarget species in the United States (see also Elliott *et al.* 1996). Yet the causality between increasing dominance of C7 in the northeast and decreasing numbers of native lady beetles has not been established (Wheeler and Hoebeke 1995).

We will refrain from debating the strategies of releasing polyphagous or generalist predators in biological control programs and of redistributing adventive generalists such as C7 that have become established through unintentional introduction with commerce. The compatibility of classical biological control and insect conservation, and the possible adverse environmental effects of biocontrol agents have already received attention from Samways (1988), Howarth (1991), Lockwood (1993), Miller and Aplet (1993), Wheeler and Hoebeke (1995), and Elliott *et al.* (1996). Instead, we simply support the philosophy of Ehler (1990) that the presence of C7 in our fauna (and now also that of *H. axyridis*) — whether the result of biocontrol releases or accidental introductions — provides ecologists a unique opportunity to assess the effects of a nonindigenous predator on indigenous lady beetles and other nontarget insects. Workers in different regions of North America are, therefore, encouraged to undertake long-term monitoring of coccinellid populations in managed and unmanaged systems. Such research, ideally coupled with baseline data obtained before establishment of adventive lady beetles, is requisite to reaching sound conclusions about the status of our native coccinellids and evaluating factors that might be contributing to any evident decline in their numbers.

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